Star Light, Star Bright: Star Characteristics Lab

Geology — Mr. Traeger

Name: ________________________ Period: ____ Date: ________________

Purpose

The purpose of this activity is to become familiar with the basic characteristics of stars.

Materials

- Computer
- Vernier Computer Interface
- Vernier Light Sensor
- Meter stick
- Nite-Ize White LED Lamp
- Masking Tape
- Starry Night High School
- Star data sheet handouts

Part 1: How Bright is the Light? Star Brightness, Distance, and Luminosity

You may have noticed that a light appears to be brighter when you are close to it, and dimmer when you are farther away. In this experiment, you will use a computer-interfaced Light Sensor to measure light intensity as you study the relationship between light intensity and distance. You will then determine the mathematical relationship between brightness and distance.

PROCEDURE

1. Set up the equipment.
   a. Get a meter stick with LED light attached at 10 cm point on meter stick.
   b. Place your Light Sensor on the meter stick and line up the LED light with the Light Sensor. Make sure the Light Sensor is set at the 0-600 Lux position.
   c. Darken the room. Do not turn on your light yet.

2. Connect the Light Sensor to the computer interface. Prepare the computer for data collection by opening the file ñ25 How Bright is Lightò from the Physical Science w Computers folder.

3. Begin data collection.
   a. Click [▶ Collect].
   b. Position the end of the Light Sensor at the 20 cm line and turn on the light on the bright setting. When the reading has stabilized, click [Keep].
   c. Type ñ10ò in the edit box (for 10 cm). This is because the light is already positioned at 10 cm and 20 cm minus 10 cm = 10 cm from the light.
   d. Click [OK]. The illumination value and the distance are now saved.
   e. Move the Light Sensor to the 25 cm line. When the reading has stabilized, click [Keep]. Enter ñ15ò (for 15 cm), and then click [OK].
   f. Repeat this procedure at 5 cm intervals through 90 cm from the light (100 cm on the meter stick.)

4. Click [■ Stop] to end data collection. Change the x axis values to include up to 100 cm. SAVE the file to your directory. PRINT one graph for each person in your group and staple it to this lab. Print page 1 of 1 ONLY to save paper!

PROCESSING THE DATA

1.. After you have printed your graph, connect the points with a smooth curve. Describe what your graph is telling you about the nature of light and brightness (intensity).

2. What is the algebraic formula for an **inverse square** relationship? How does this formula ñfitò with your graph you made? How does this formula mimic Newtonõs Law of Gravity?

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3. If light intensity and distance fit an inverse square relationship, doubling the distance would cause light intensity to be 1/4 as great. See how well your data agree by **dividing the light intensity value at 60 cm by the light intensity value at 30 cm**. Show your work below. **How close is your value to 0.25 (1/4)? Does your data support an inverse square relationship for light intensity and distance?**

4. The energy output of a star is known as LUMINOSITY. It depends on the temperature of a star and the size (radius) of a star. Hotter stars are more luminous and bigger stars are more luminous according to the equation Luminosity (watts) = $4\pi R^2\sigma T^4$, where R = radius in meters, σ = Stefan-Boltzmann constant = 5.67 X 10^{-8} W m^{-2} K^{-4} and T = Temperature in degrees Kelvin. This means that doubling the radius of a star increases its luminosity by _______________ times. Doubling the temperature of a star increases its luminosity by _________________ times.

5. The brightness of a star's light is called apparent brightness. It is apparent because it is what we see. The apparent brightness of a star (b) in W m^{-2} = Luminosity of a star (L) in Watts divided by 4´ d^2 where d = distance to the star in meters. The apparent brightness of our Sun is 1370 W m^{-2}. This means that a 1 m^2 solar panel placed at the top of our atmosphere would receive 1370 Watts of power from the Sun. If this is true, then what is the Luminosity of our Sun in Watts if our average distance from the Sun is 1.50 X 10^{11} meters? How many 100 Watt light bulbs is this equal to? Show the math.

6. Earth has often been referred to as the Goldilocks planet. It's not too hot, it's not too cold, it's juuuuuust right! If this is true, then what would happen to Earth if we moved it farther from the Sun? Closer? How does this affect the search for extrasolar life-bearing planets by a telescope like Kepler?

7. Most stars that you see in the night sky in Los Angeles light pollution are much more luminous than our Sun. Spica, in the constellation Virgo, is 12,100 times more luminous than our Sun. If Spica were to become our host star, then how much farther away would we need to be from Spica to get the same apparent brightness of 1370 W m^{-2}? Show work. *Hint*: Use the formula stated in question #5.

8. After doing this experiment, what are the two factors that affect the apparent brightness of a star as seen from Earth? See formula stated in #5.

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Part 2: Star Characteristics (Use the Star Data Sheets to answer these)

1. What is apparent magnitude? What two factors does it depend on?

2. What is a light year?

3. How many years did it take light to get to Earth from the star Pollux?

4. What is the name of your birthday star? How many light years from Earth is it? What does the concept birthday star mean? See birthday star website here: http://outreach.jach.hawaii.edu/birthstars/

5. How far away (in kilometers and miles) is one light year if the speed of light is 300,000,000 meters per second? Show the math. Remember that there are 1.6 kilometers in every mile.

6. Parallax is how we determine distances to stars within 326 light years of Earth. Describe parallax by drawing a diagram of it. Stick a pencil out in front of you and open and close your left and right eye. Describe what you see. What happened to the parallax angle the farther away you moved the pencil? What happened to the parallax angle the closer you moved the pencil?

7. Calculate the distance in parsecs and light years for the following stars. Distance in parsecs = 1/parallax angle. There are 3.26 light years in every parsec.

Star Name	Parallax angle (arcsecs)	Distance in parsecs	Distance in light years
Alpha Centauri	0.732		
Alpha Canis Majoris	0.379		
Alpha Aquiliae	0.194		
Alpha Canis Minoris	0.286		

8. What are Cepheid Variable Stars and how do we use them to find distances to stars greater than 326 light years from Earth?

9. What star do we compare the mass and radius of other stars to when describing their sizes?

10. How does the temperature of a star affect its color according to Wien's Law? Remember that Wien's Law says that the wavelength of maximum emission of a star ($\lambda_{maximum}$) = 2,900,000 divided by the temperature of a star in degrees Kelvin.

11. Categorize the spectral classes OBAFGKM (Oh Be A Fine Girl(or Guy), Kiss Me.) and tell me what temperature range each star falls in to.

Spectral Class	O	B	A	F	G	K	M
Temperature Range (°C)							
Color							
Elements							

12. What is absolute magnitude? What is the reference distance for absolute magnitude? What single factor does absolute magnitude depend on?

13. Every decrease of 1 in apparent or absolute magnitude of a star will result in how much of an increase in brightness?

14. The sun has an apparent magnitude of -25.5 and an absolute magnitude of +4.8. Explain why this is.

15. How many times brighter is the sun's apparent magnitude of -25.5 compared to Betelgeuse's apparent magnitude of +0.5? Show the math!

Homework for tonight! Go outside tonight after dark with your star finder and some binoculars if you have them. A small flashlight (preferably with a red filter) is also needed. Make sure to hold the star finder over your head and point the North arrow in the direction of the mountains. **On a separate piece of paper**, do the following: A) List the names of the constellations/star groups you can identify. B) What was the time and location where you observed? (Note: do this on the next night that it is clear if it is cloudy tonight.) C) What are some of the brightest stars in the sky and where are they? Just say the location in the sky if you do not know the name. D) Find a star that appears red. Where is it? E) Find a star that appears yellow. Where is it? F) Find a star that appears blue. Where is it? G) What does the color of a star tell you about that star? H) Are the brightest stars burning the hottest? Why or Why not? I) How can you tell the difference between the planets (Venus, Jupiter and Saturn) and the stars?

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Part 3: Rating 10 Stars and Spectral Classes

1. Using the star information sheets or Google Sky to fill in the following chart.

Star Name	Apparent Magnitude	Distance in light years	Mass (Solar masses)	Size (Solar diameters)	Temperature (Kelvin)	Luminosity (compared to sun)	Absolute Magnitude	color	Spectral class (O, B, A, F, G, K, M)	Type of Star (red giant, main sequence, etc.)
Rigel										
Arneb										
Procyon										
Betelgeuse										
Capella										
Sirius										
Aldebaran										
Castor										
Alnitak										
Pollux										

2. Arrange each of the ten stars from hottest to coldest. Put the spectral class next to the name of each star.

3. What is the spectral class of our sun?